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Influence of Growing Conditions on Chlorophyll Content, Photosystem II Activity and Productivity of Tomato Varieties

K.Z. Hasanova[1], A.T. Gaziyev[1], I.V. Azizov[2*]

[1]*Azerbaijan State Agrarian University, Ganja, Azerbaijan;*
[2] *Laboratory of Photochemistry of Chloroplasts, Institute of Molecular Biology & Biotechnologies, Azerbaijan National Academy of Sciences, Baku AZ1073, Azerbaijan;*
**E-mail: ibrahim.azizov47@gmail.com*

The present work was carried out to determine the effects of manure and $CaCO_3$ on growth, content of photosynthetic pigments, activity of photosystem II (PS II) and yield parameters of six varieties of tomatoes. The plants were grown under conditions of closed (greenhouse) and open ground, with manure applied in the calculation of 500 g and $CaCO_3$ (chopped eggshell) 50 g per 1 m^2 of soil. It was revealed that the tomato varieties Tolstoy and Volgograd have a high photosynthetic apparatus activity and productivity, which can be used in breeding works.

Keywords: *Tomato varieties, manure, chlorophyll, carotenoids, PSII, yield*

INTRODUCTION

Tomato is one of the valuable vegetable crops grown all over the world to provide the needs of the population with valuable natural compounds, as well as for processing in canneries. Growing tomatoes in winter greenhouses is of enormous economic importance for providing the population with vitamins C, B1, B2, B3, PP, as well as elements of potassium, sodium, magnesium, phosphorus, iron, sugars, apple and citric acids and proteins. Tomatoes are demanding soil fertility, especially phosphorus, nitrogen and potassium. In the seedling period, tomato intensively consumes potassium and phosphorus, later nitrogen. Plants use nitrogen to form vegetative organs, especially in the period from sprouting to flowering. The consumption of phosphorus is mainly associated with the growth of the root system, fruit and seeds. Potassium is especially needed during the period of growth and maturation of fruit. Tomatoes also need other microelements: sulfur, iron, boron, manganese and others. To obtain a high yield, it is necessary to increase the concentration of carbon dioxide, which can be increased by adding manure to the soil where tomatoes will grow. It is considered that first of all it is important to select organic materials instead of using synthetic fertilizers in organic vegetable growing in order to increase soil productivity. Therefore, green manure, composts and other organic fertilizers should be used in cultivation of organic vegetables (Harun, 2017). Manure is an environmentally friendly and economically beneficial organic fertilizer. In experiments carried out using sandy soil, with the addition of organic fertilizers, plant growth was markedly accelerated in comparison with control plants (Zhang et al, 2011; Cui et al., 2002). Organic fertilizers also neutralized the acidity of the soil (Cui et al., 2003) and increased the activity of catalase (Chen et al., 2003). The addition of various stimulants improves the quality of the crop (Yongxia et al., 2013), stress tolerance (Giri et al., 2003). It is known that calcium is one of the necessary elements for the growth and development of plants, and it also removes the toxic effect of harmful ions for plants, such as sodium ions. In earlier studies it was shown that providing additional Ca had reduced some of the detrimental effects of Na on tomato and other crops (Navarro et al., 2005; Francesco et al., 2009).

Based on this, the purpose of our studies was to study the effect of manure and $CaCO_3$ on the growth, photosynthesis and productivity of different varieties of tomato.

MATERIALS AND METHODS

The objects of study were six varieties of tomato, grown under the conditions of a greenhouse and open ground. The manure was applied with the calculation of 500 g and $CaCO_3$ (chopped eggshell) 50 g per 1 m^2 of soil. In the phases of plant development, leaf samples were taken to determine the content of chlorophyll and carotenoids. The efficiency of the photosystem (Fv/Fm) was determined using a photosynthesis analyzer (PAM, Germany). The activity of photosystem II (PS II) was determined on the polarograph (OH103) by releasing oxygen with application of the Clark electrode. (Grishina, 1971). The content of

chlorophylls and carotenoids was determined on the spectrophotometer (Multiscan GO, Germany) by trituration the leaves in 80% acetone, measuring the absorption at 645, 663, and 440, using the Wettstein and Arnon coefficients (Khanishova et al., 2008). Data analysis and statistical analysis were conducted using Microsoft Excel. Statistical analysis was performed with the aid of the Statgraphics Plus 5.1 statistical package. The means of values were compared by Duncan's multiple range test (p=0.05).

RESULTS AND DISCUSSION

The results of experiments on the effect of manure on the content of photosynthetic pigments and on fluorescence parameters are shown in Table 1.

As can be seen in Table 1, manure positively affects the content of chlorophyll a + b and carotenoids. The ratio a/b increased, which indicates an accelerated synthesis of chlorophyll a. The manure also contributed to an increase in the activity of the photosynthetic apparatus of tomatoes (Figure). Photosystem 2 activity increased by 65% in Tolstoy, that markedly exceeded the activity in other varieties. To measure the physiological state of plants on whole leaves, the values of the ratio Fv/Fm were measured. As can be seen in the table, the values of Fv/Fm in control and experimental plants are significantly different. Inter-variety differences are also observed. Our data are consistent with generally accepted opinions that the values of the parameter Fv/Fm above 0.74 reflect the favorable state of the plants.

To study the effect of calcium on the growth and development of tomatoes, we used a chopped eggshell as organic calcium. The results of experiments obtained using organic calcium are given in figure.

According to several authors (Mahmoud et al., 2014; Saidu et al., 2011; Tiamiyu et al., 2013; Ayoub, Afrah, 2014) manure when decomposed increases both macro and micro nutrients as well as enhances the physical and chemical properties of the soil; this led to its high vegetative growth. The nonsignificant difference observed in the treatments supplied with goat and cow dung with control treatment could be either there were some nutrients already present in the soil or the plants need were satisfied with the quantity of nutrients present in the soil. Tomato grown on poultry manure and sown at the right time performed better in terms of the height of the plant than the other sources of organic manure and sowing date. This shows that poultry manure was readily available and in the best form for easy absorption by the plant roots, hence there was a boost in the morphological growth of the plant. The obtained results corroborated the finding of in okra (*Abelmoschus esculentus* L.) production in which they reported that organic manure, especially poultry manure could increase length of crops when compared with other sources of manures and sowing dates.

Table 1. Effect of manure on content of chlorophyll, carotenoids and the efficiency of the photosystem II

Variety	Chlorophyll(a+b)mg/g		Carotenoids mg/g		F_v / F_m	
	Control	Experiment	Control	Experiment	Control	Experiment
Rally	0.97*	1.5	15.2	16.8	0.7	0.8
Tolstoy	0.97	1.8	15.2	16.9	0.7	0.8
Volgograd spring	0.79	1.7	10.9	13.2	0.8	0.8
Volgograd autumn	0.81	2.0	12.3	14.5	0.7	0.8
22-74	0.50	1.1	21.1	23.2	0.5	0.6
Falkon	1.10	1.4	20.8	22.4	0.5	0.6

* Each value represents the mean ± SD (standard deviation) for the mean n = 3 independent experiments p = 0.05.

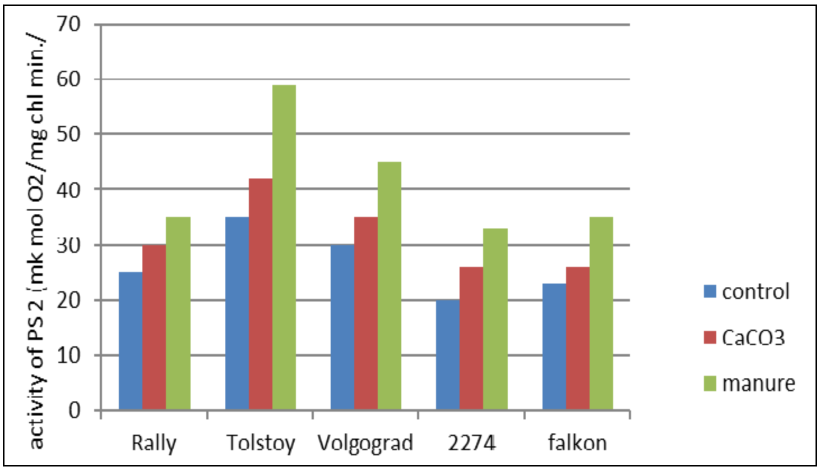


Fig. Effect of $CaCO_3$ and manure on activity of PS2 of tomatoes.

Table 2. Effect of manure on height and yield of tomato plants

Variety	Variant	Height, cm	Harvest of a single plant, g	Harvest, m^2 / kg	average fruit weight, g
Rally	control	51	750 ± 61	15	40
	manure	60	840 ± 68	17	45
Tolstoy	control	65	1200 ± 72	19	46
	manure	74	1370 ± 75	23	50
Volgograd spring	control	62	1300 ± 68	21	48
	manure	66	1450 ± 71	25	52
Volgograd autumn	control	55	1060 ± 65	19	44
	manure	60	1270 ± 68	22	49
22-74	control	45	550 ± 34	15	42
	manure	52	670 ± 45	18	45
Falkon	control	48	630 ± 46	16	43
	manure	64	750 ± 55	19	46

* Each value represents the mean ± SD (standard deviation) for the mean n = 3 independent experiments p = 0.05.

The non-significant effect of manure sources on fruit length could be due to the effect of these sources of organic manure on enhancing vegetative growth. All the nutrients supplied by the different manure sources might have been diverted to vegetative growth. This could be due to their bulkiness and higher amount of nutrients already present in the soil could contribute to this phenomenon.

The organic fertilizer affected the morphometric parameters of plants- stem diameter, wet weight of the aboveground parts of plants (Table 2). As can be seen in Table 2, there are differences between the varieties. The tomato variety Tolstoy has the highest morphometric parameters. Our studies have shown that the application of organic fertilizer has unequivocally increased the growth, the diameter of the stem, the wet weight of the aboveground and underground parts, as well as the productivity of tomatoes. According to the literature data, organic fertilizer improves the water potential of the soil, facilitates the entry of elements of mineral nutrition into the roots of plants (Chen et al., 2003). During the drought, manure prevents evaporation of water and promotes moisture retention in soil capillaries around the root system of plants. In drought conditions, varietal characteristics are also revealed: some varieties use mineral elements more intensively, others more slowly. In our experiments the Volgograd and Tolstoy varieties were the most intense, which, under identical conditions of supply with organic fertilizer, proved to be the most productive.

CONCLUSION

When growing 6 different varieties of tomato with the introduction of organic fertilizer the most productive were the varieties Tolstoy and Volgograd, which can be used in breeding for obtaining more highly productive varieties.

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Becərilmə Şəraitinin Tomat Sortlarında Xlorofilin Miqdarına, Fotosistem II -nin Fəallığına və Məhsuldarlığa Təsiri

K.Z. Həsənova[1], A.T. Kazıyev[1], İ.V. Əzizov [2]

[1]*Azərbaycan Dövlət Aqrar Universiteti, Gəncə, Azərbaycan*
[2]*AMEA Molekulyar Biologiya və Biotexnologiyalar İnstitutunun Xloroplastların fotokimyası laboratoriyası*

Təqdim olunan işdə peyinin və $CaCO_3$-ın 6 tomat sortunda fotosintez piqmentlərinin miqdarına, fotosistem II -nin fəallığına və məhsuldarlığına təsiri öyrənilmişdir. Bitkilər qapalı (istixana) və açıq torpaq şəraitində 1 m^2 sahəyə 500 q peyin və 50 q $CaCO_3$ (üyüdülmüş yumurta qabığı) verilməklə əkilmişdir. Müəyyən edilmişdir ki, Tolstoy və Volqoqrad tomat sortları yüksək fotosintez fəallığına və məhsuldarlığa malikdirlər və onlar seleksiya işlərində istifadə oluna bilərlər.

Açar sözlər: *Tomat sortları, peyin, xlorofil, karotinoidlər, fotosistem II, məhsuldarlıq*

Влияние Условий Выращивания на Содержание Хлорофилла, Активность Фотосистемы 2 и Продуктивность Сортов Томата

K.Z. Гасанова[1], A.T. Казиев[1], И.В. Азизов[2]

[1] *Азербайджанский государственный аграрный университет, Гянджа, Азербайджан*
[2] *Лаборатория фотохимии хлоропластов Института молекулярной биологии и биотехнологий НАН Азербайджана*

Настоящая работа проводилась с целью определения влияния навоза и $CaCO_3$ на рост, содержание фотосинтетических пигментов, активность фотосистемы 2 (PS 2) и урожайные показатели шести сортов томатов. Растения выращивали в условиях закрытого (тепличного) и открытого грунта с внесением на 1 $м^2$ почвы 500 г навоза и 50 г CaCO3 (расколотая яичная скорлупа). Выявлено, что сорта томата Толстой и Волгоград обладают высокой активностью фотосинтетического аппарата и продуктивностью, и могут быть использованы в селекционных работах.

Ключевые слова: *Томаты, навоз, хлорофилл, каротиноиды, фотосистема 2, продуктивность*